Potential Economics of Nuclear Small Modular Reactor Technology for Alaska

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University of Alaska Anchorage

Institute of Social and Economic Research

Mission Statement:

ISER enhances the well-being of Alaskans and others, through non-partisan research that helps people understand social and economic systems and supports informed public and private decision-making.

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Research Area: Energy and Environment

Steve Colt, associate professor of economics and former ISER director, focuses on energy economics, isolated utility systems, and the economics of ecosystem services—including tourism and recreation.

Matt Berman, professor of economics, assesses the economics of the petroleum industry and other resource industries.

Ginny Fay, assistant professor of economics, is a resource economist and biologist with special interests in energy and natural resource economics, tourism and recreation, and community development.

Tobias Schwörer, research associate, has studied many energy issues; he is also interested in the economic valuation of biodiversity.

Ben Saylor is a computer programmer and research associate who has done analysis for a variety of energy projects.

Alejandra Villalobos Meléndez, research associate, studies the economics of renewable energy development and sustainability.

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Overview

1. Introduction
2. Methods
3. Cost definitions
4. Assumptions
5. Uncertainty
6. Results
7. Conclusions

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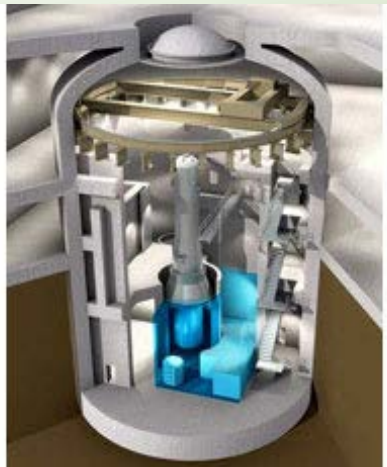
Small Modular Reactor (SMR) Economic Screening Analysis

- SMRs are nuclear power plants smaller than 300 MW.
- Compact design, factory-fabricated, transportable by rail and truck.
- Modeling goals:
  - If and where do different SMR technologies are economic energy options for Alaska
  - Identify how economics shift with varying capital and energy costs
- Analyzed Railbelt and rural hubs



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Methods

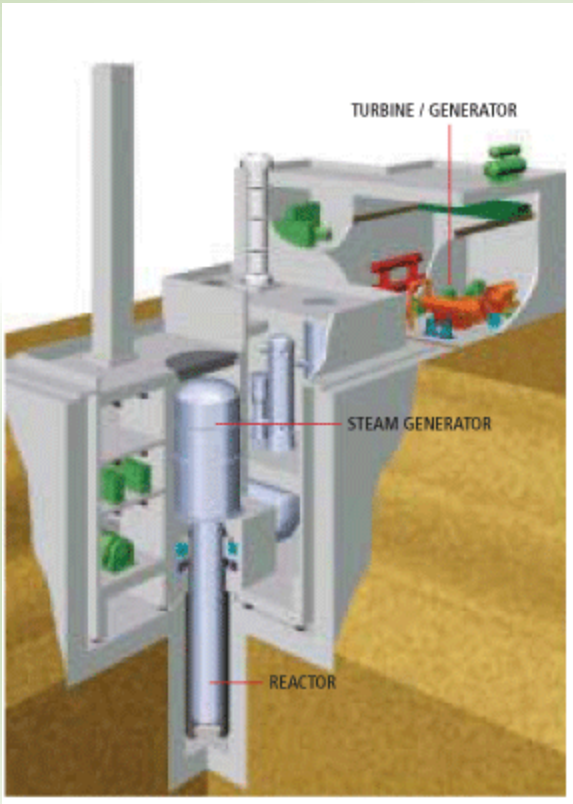
- Screening model adapted from economic model used in Galena analysis
- Improvements:
  - ISER components of fuel cost studies
  - New data on space heating requirements
- Generalization:
  - Spreads high fixed costs
  - Considers mainly base load
  - Models steam sales to public buildings

Methods, cont.

- Assumes households use conventional space heat until electric rates are low enough to create savings through electric heat.
- If households switch to electric heat, the utility will be able to sell more kWh and rates drop.

Cost Definitions

- Project island cost
- Licensing cost
- Labor cost
- Operation & Maintenance cost
- Decommissioning cost
- Fuel cost
- Major overhaul, de/mobilization
- Distribution & administration
- Backup generation



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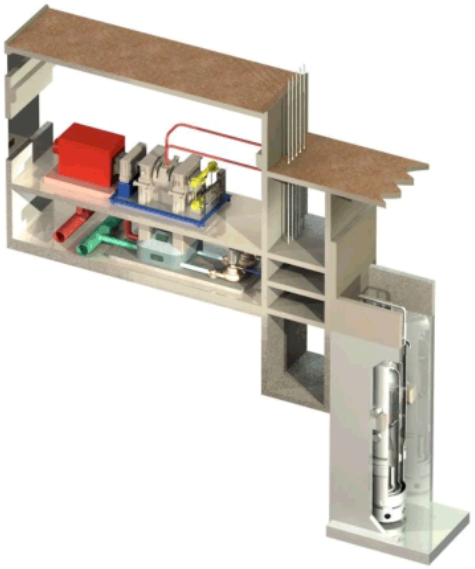
Common Assumptions

- Discount rate: 3%
- Population growth: 0%
- Project horizon: 60 years
- Availability: 90%
- Power island cost: $8,000-$12,000/kW
- Licensing cost per reactor: $50-70 million
- Annual labor cost: $3.9 million
  - 5 shifts with 7 operators, 8 security staff

Common Assumptions, cont.

- Parts, operator training, etc.: $0.015/kWh
- Decommissioning cost: $0.005/kWh
- Return to operator: 15% of net cost
- Distribution and admin.
  - Railbelt: 4 cents/kWh
  - Rural Alaska: $700,000/year
- Diesel generation:
  - Capital cost: $2500/kW
  - O&M 8 cents/kWh



Single-unit side view of the NuScale system design

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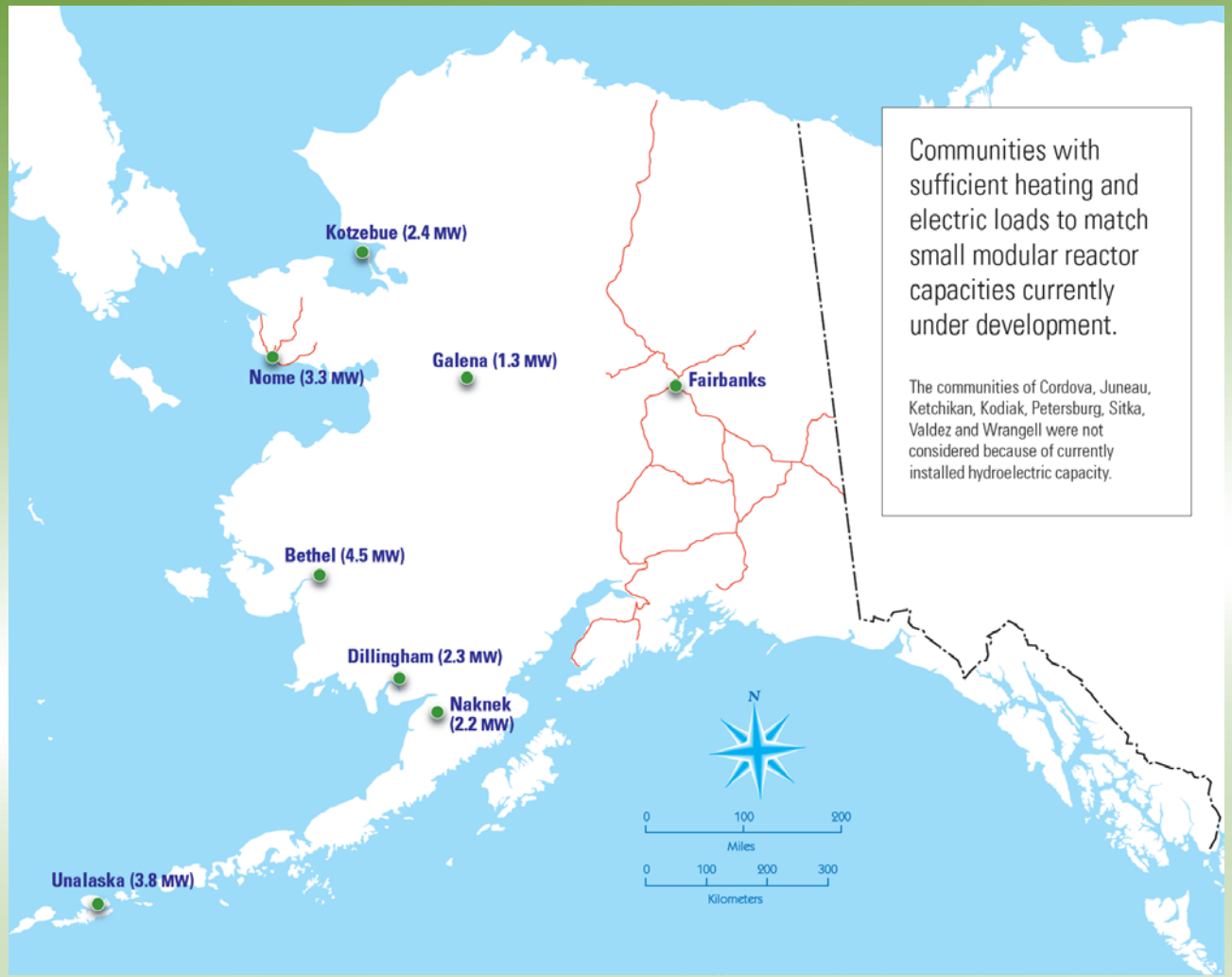
Fuel and Carbon Price Forecasts

- Energy Information Administration
  - Current crude oil price forecast
  - Current natural gas price forecasts
- MIT and ISER carbon price assumptions
  - 5% annual increase starting in 2010
  - low $9.48, mid $15.20, high $33.87 /metric ton
- ISER fuel and natural gas price forecast by community

Locations of Screen Analysis



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Reactor-specific Assumptions

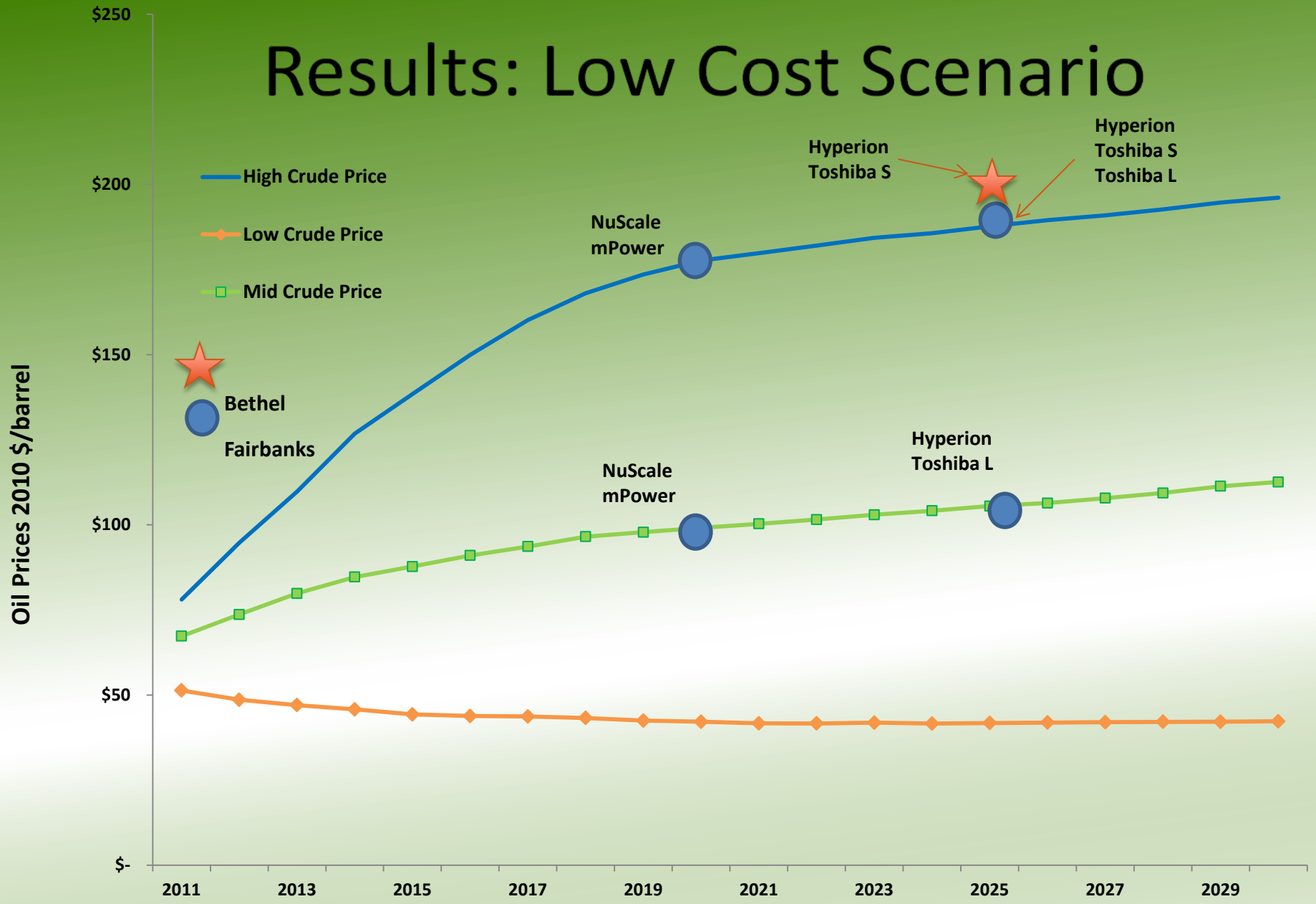
Estimated/assumed costs and parameters	mPower	NuScale	Hyperion	Large	Small
Year expected available	2020	2020	2025	2025	2025
Electric capacity [MW]	125	45	25	50	10
Thermal capacity [MW]	375	160	70	150	30
Power facility ($million)					
low	562.5	202.5	112.5	225.0	45.0
med	750.0	270.0	150.0	300.0	60.0
high	1,000.0	360.0	200.0	400.0	80.0
Years per fuel cycle	4	2	9	15	30
Levelized/annualized fuel cost ($million)					
low	5.3	2.5	1.1	13.1	4.4
med	7.8	3.7	1.7	19.6	6.6
high	9.9	4.9	2.2	29.0	9.9
Fuel cost per kWh ($)					
low	0.005	0.007	0.005	0.031	0.051
med	0.008	0.010	0.008	0.046	0.077
high	0.010	0.013	0.011	0.069	0.115

Toshiba 4S

Sources of Uncertainty

- Cost estimates – "guess work"
  - technology in early development stage
  - modularity creates uncertainty for manufacturing
- Fuel price forecasts and variations in fuel prices
- Accounting for some uncertainty by applying:
  - Sensitivity analysis
  - Monte-Carlo simulation

Results: Low Cost Scenario



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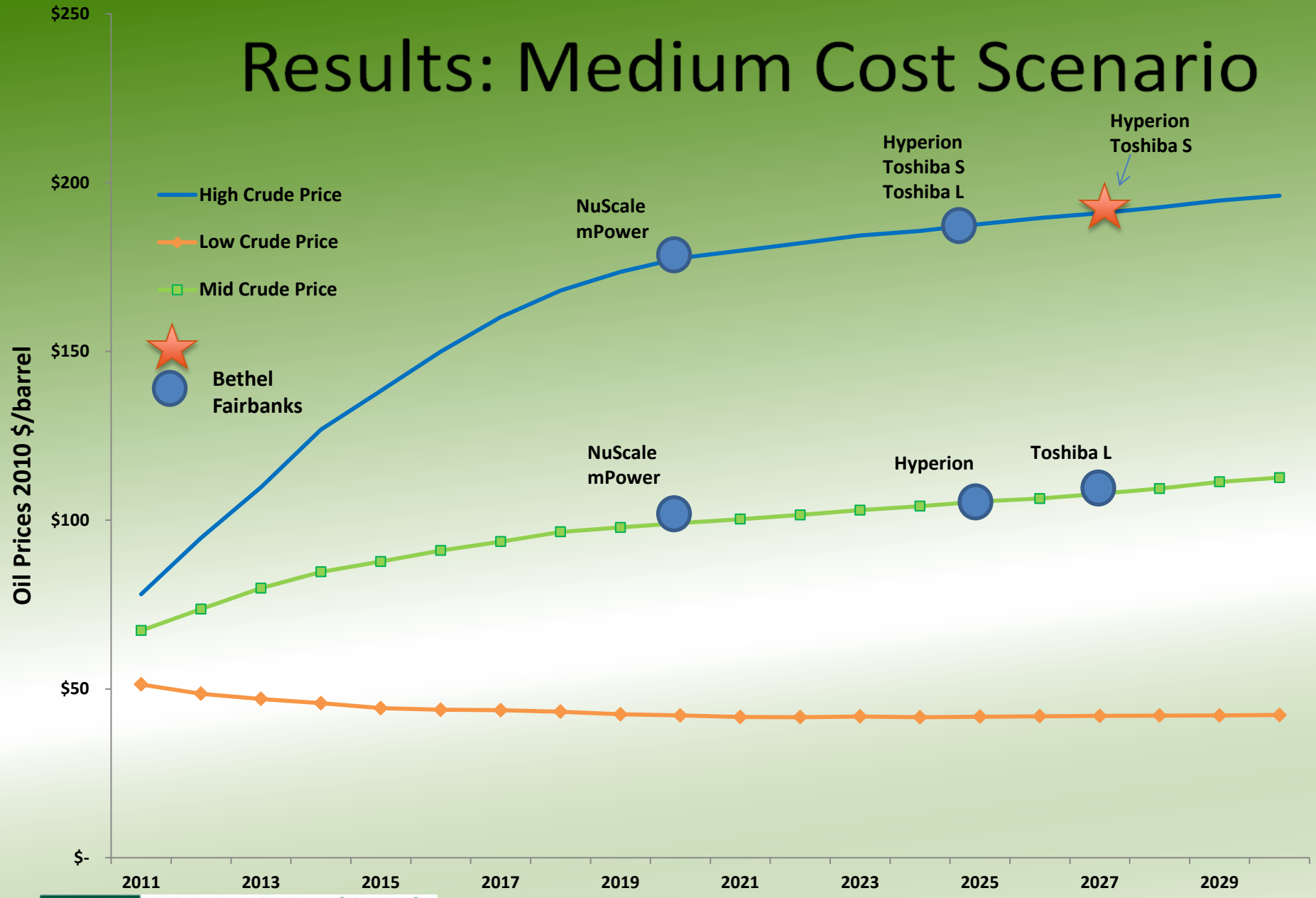
Results: Medium Cost Scenario



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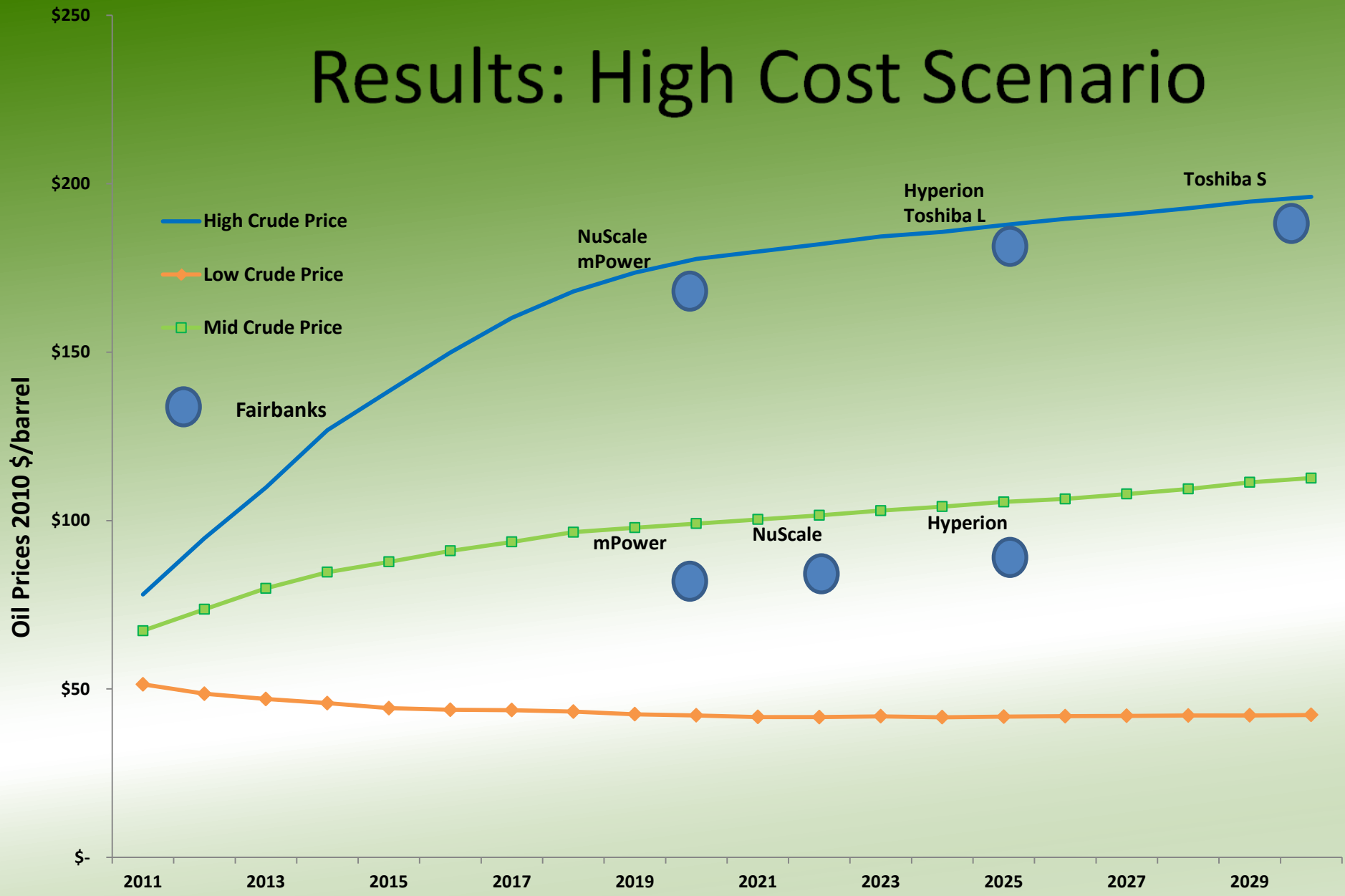
Results: High Cost Scenario



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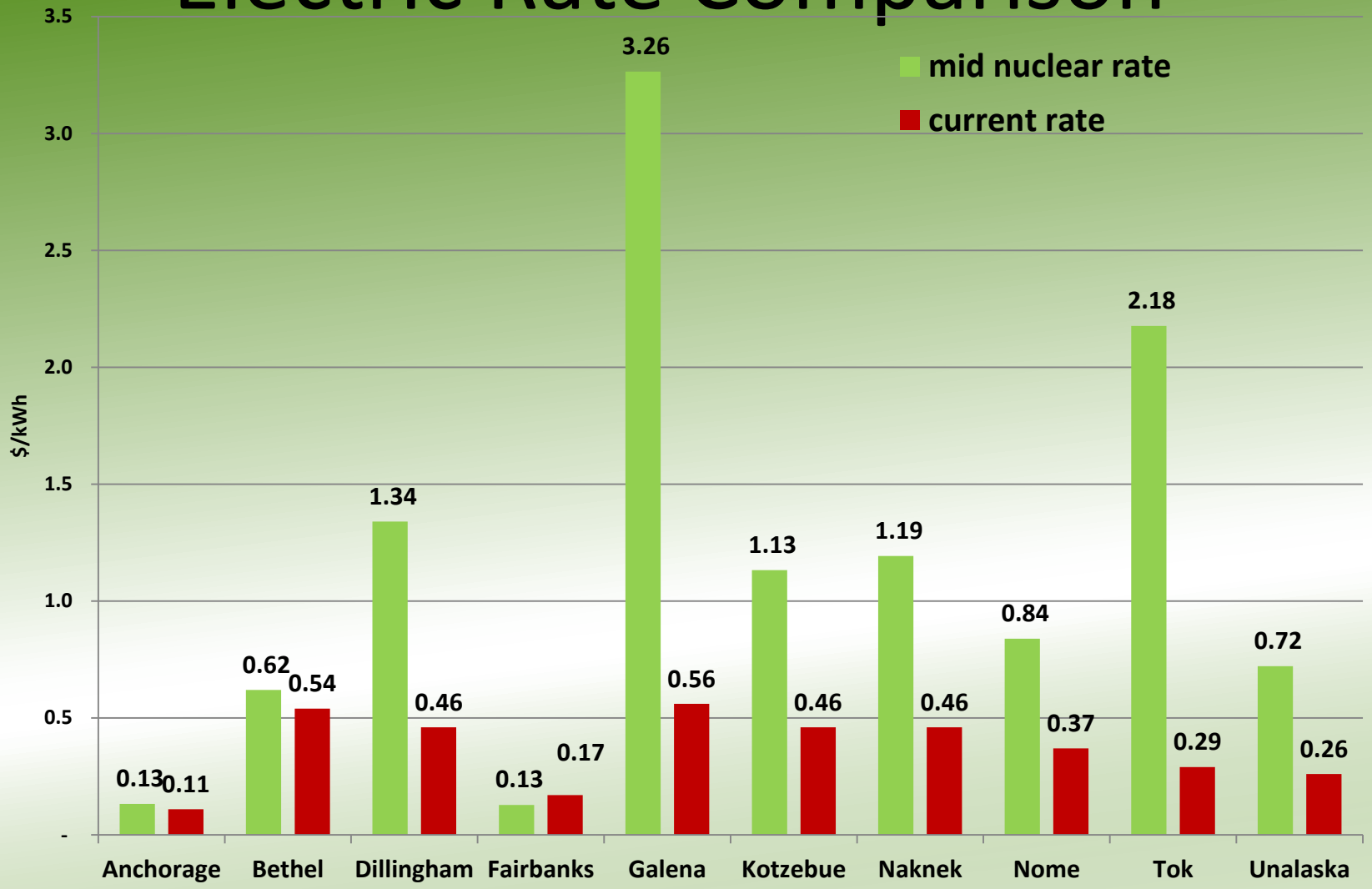
Assumes mid case crude prices ($70-120/bbl).

Electric Rate Comparison



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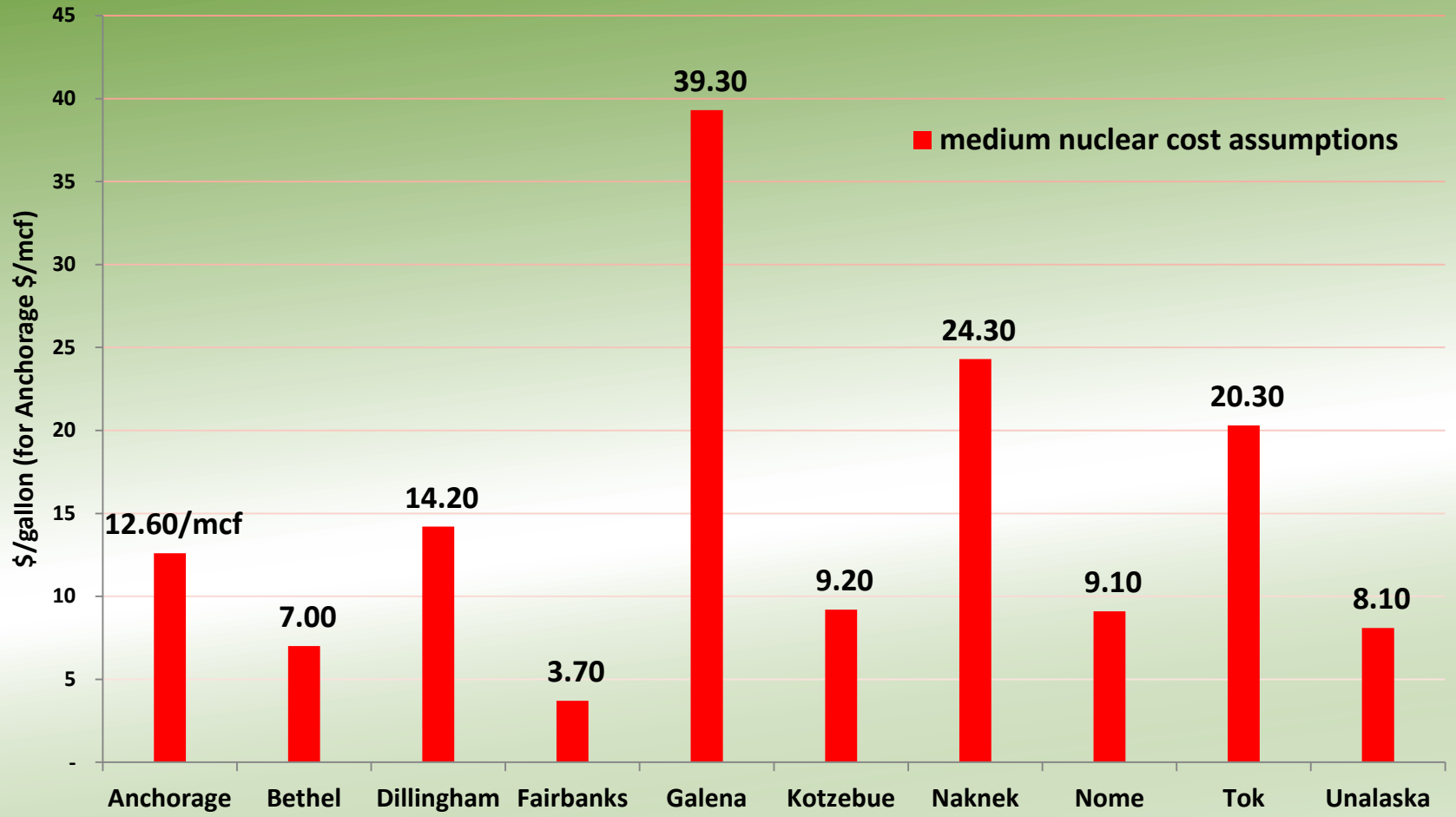
Fuel Price Thresholds

(at medium nuclear cost)



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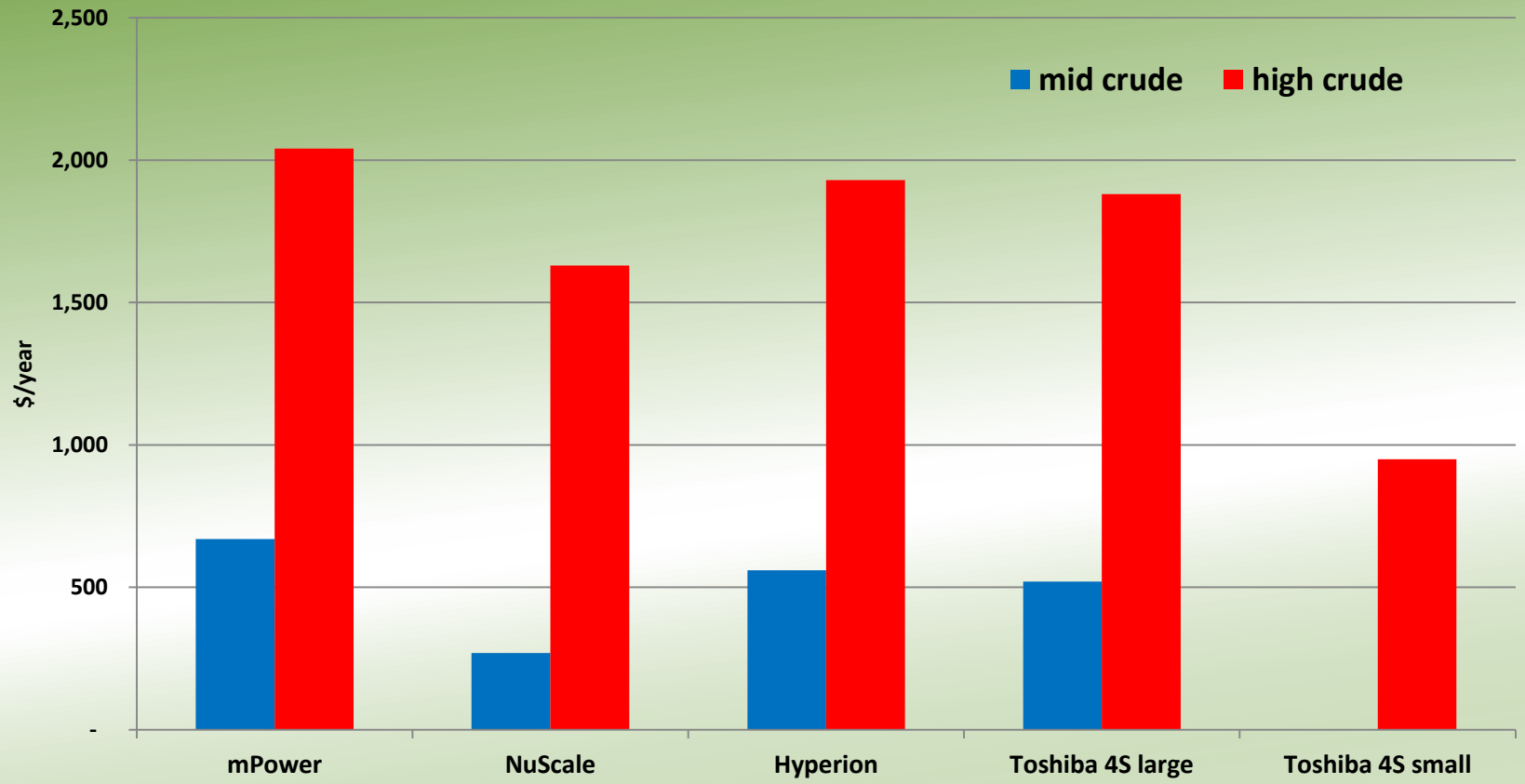
Annual Household Savings in Fairbanks

(at medium nuclear cost)



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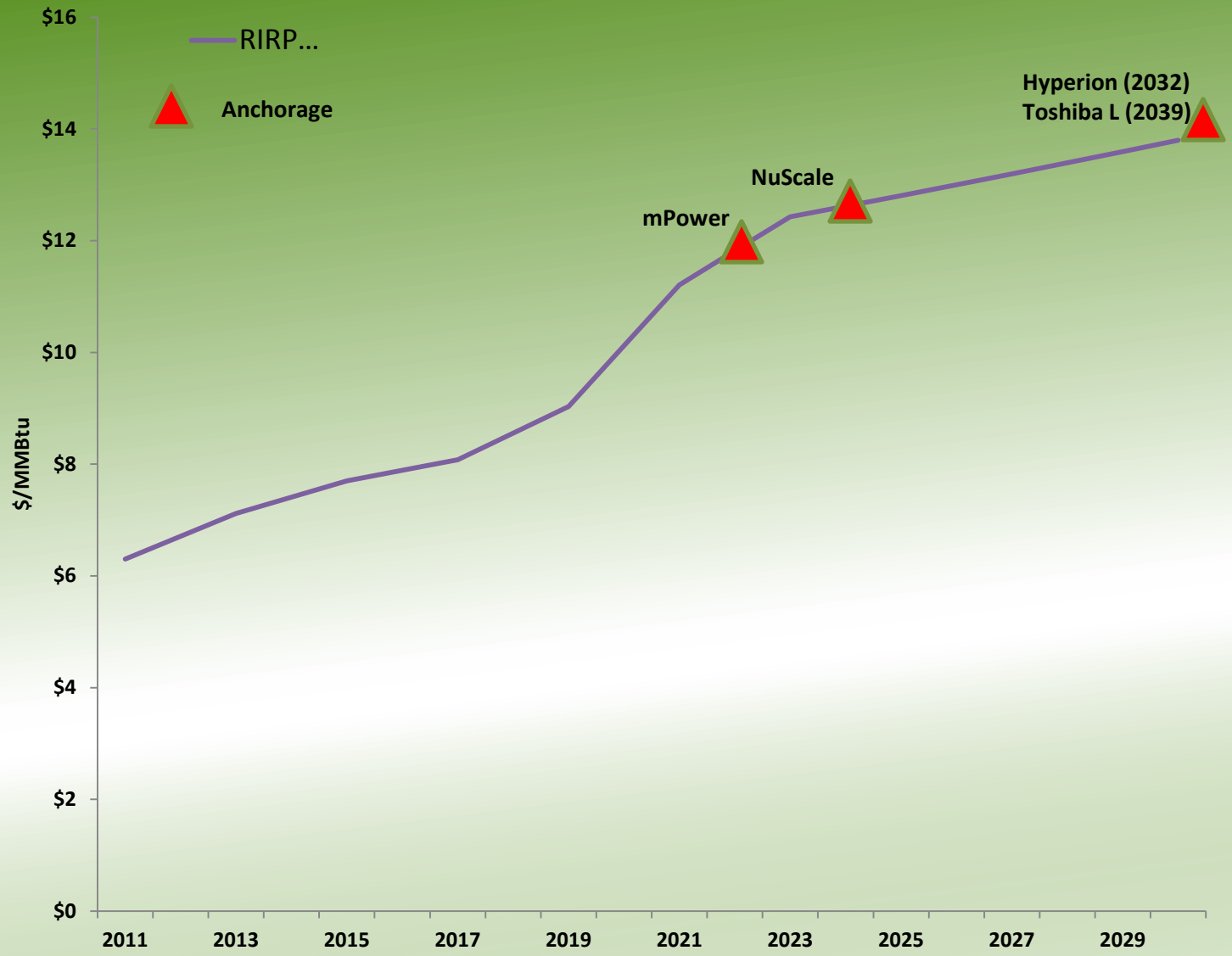
Anchorage RIRP Natural Gas Price Forecast



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Conclusions

- Cost estimates are highly uncertain
  - particularly for liquid metal cooled reactors
  - n^{th} mover estimates
- Deployment in Alaska after significant "learning by doing"
- Capacity needs to fit community load
- Most suitable in Fairbanks
- Electric heat sales and steam heat sales contribute to economic viability

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